

Use And Disposal Of Polystyrene In California

A Report To The California Legislature



October 2003



Zero Waste—You Make It Happen!

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Introduction

California is faced with the significant challenge of safely and effectively managing the solid waste generated by nearly 35 million people in one of the largest economies in the world. Plastics are a major part of the California economy. In 2001, the California plastics industry employed more workers (152,335) than any other state and was ranked second in the nation in the value of shipments (\$27.8 billion). California also leads the nation in both employment and the value of shipments from polystyrene (PS) foam product manufacturing. (Source: 1) Ironically, one of the difficult materials in the state to manage is plastic, especially certain types of polystyrene.

Expanded Polystyrene (EPS) transportation packaging represents approximately 20 percent of PS produced nationally and it can be, and to some degree is, recycled. EPS transportation packaging is currently being recycled at 12.4 percent nationally and an estimated 19 percent in California. (Source: 2) That is much better than the 5 percent national recycling rate for all plastics. However, additionally opportunities exist to work with the EPS transportation packaging industry to voluntarily increase recycling to a much higher level.

Commercial and institutional (including food service PS) products represent 42 percent of PS production. Unfortunately, food service PS is not being recycled and presents unique challenges in its management due in part to being contaminated with food residue. Although there have been attempts to recycle food service PS, its current design does not lend itself to minimizing end-of-life environmental impacts.

Food service PS, by its nature, has a useful life that can be measured in minutes or hours. Yet, it takes several decades to hundreds of years to deteriorate in the environment or landfill. It also represents a significant challenge as litter. Not only does the food service PS break into smaller pieces that may be ingested by wildlife, but materials may also be contaminated with food that decays, creating a health hazard.

PS that is illegally released as litter may also find its way through the storm drain system and into the marine environment. As an example, the Los Angeles Regional Water Quality Control Board issued a Trash Total Maximum Daily Load (TMDL) order for the Los Angeles River requiring zero measurable trash in the storm drain system within 10 years. The County of Los Angeles and the cities affected by the TMDL estimate having to spend \$180 million, or more, to reduce the amount of trash in the storm drains in an effort to partially comply with the order. (Source: 3)

An estimated 0.8 percent (by weight) of the material disposed in California's landfills is PS. However, because of its light weight, the volume of PS disposed in landfills is much higher than the weight amount would tend to indicate. For example, weight/volume estimates range from 9.6 pounds/yard³ for expanded polystyrene (EPS) packaging to 22.2 pounds/yard³ for other forms of PS. This compares to 100 pounds/yard³ for cardboard and 2,160 pounds/yard³ for broken glass. (Source: 4) Accordingly, effective management of PS can have a positive, albeit small, impact on the available space at California's landfills. It can also mitigate some of the adverse environmental impacts associated with litter.

Legislative Requirement

Governor Davis signed SB 1127 (Karnette), Chapter 406, Statutes of 2001, in September 2001. This bill required the California Integrated Waste Management Board (CIWMB) to study the use and disposal of polystyrene (PS) in California. This report, required by the legislation to be submitted to the Legislature, presents findings and recommendations from the study.

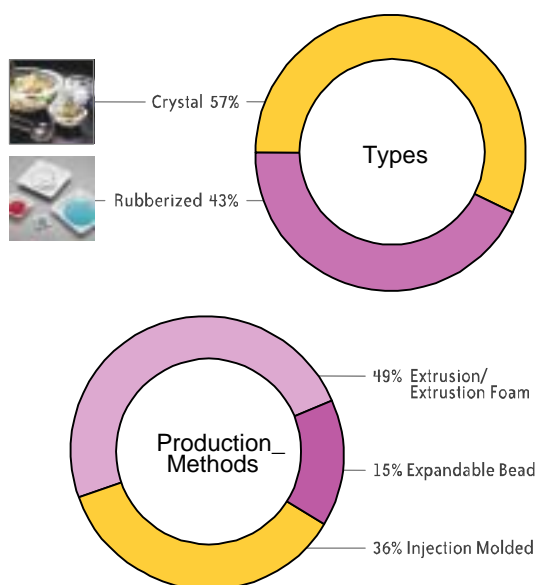
SB 1127 required that the report must:

1. Analyze how consumers are using PS before it enters the waste stream, including, but not limited to, food service and transport packaging. The report must cover the amount of PS being landfilled annually in the state, the amount being reused and recycled, and the related environmental and public health implications, if any.

2. Recommend methods for source reducing, reusing, and recycling, and for diverting PS from the state's landfills.
3. Address the cost of the disposal of PS in volume and weight terms.
4. Examine and identify current and potential markets for recycled PS products.

Concurrent with the Legislative process for SB 1127, the CIWMB and Department of Conservation (DOC) initiated a plastics white paper project to define current California plastics issues and provide a menu of policy options. The CIWMB and DOC were interested in: (1) increasing the plastics recycling rate, (2) increasing the use of recycled plastics, and (3) promoting plastics resource conservation. Information on plastics, including PS, was obtained from a variety of sources and a wide range of stakeholders (including the plastics industry, environmental community, local and state government, waste haulers, processors, and others). Stakeholders have reviewed both the plastics white paper and this PS report.

Exhibit 1. Polystyrene Types and Production Methods



Types and Amount Produced

Polystyrene (PS) comes in many types and forms and is used in a variety of applications. However, the two major types are “general-purpose” (also known as “crystal”) PS and “high-impact” (also known as “rubber-modified”) PS. When a blowing agent (usually pentane) is added to general purpose PS it is referred to as “expandable (or “expanded”) polystyrene” (EPS). Approximately 57 percent of the PS consumed in the U.S. in 1999 was general-purpose. Table 1 summarizes various PS types and typical products. Examples of general-purpose PS include CD jewel cases, salad “clamshells,” and cutlery. Examples of high-impact PS (HIPS) include horticultural trays, yogurt containers, office equipment housings and supplies. Examples of EPS, sometime incorrectly referred to as “Styrofoam®,” include beverage cups, packaging for electronics, and loosefill “peanuts.”

PS's two major types and four major production methods are reflected in Exhibit 1: extrusion, extrusion foam, injection molded, and expandable bead. Extrusion PS includes agricultural trays, clamshells, meat trays, dairy containers, and decorative panels. Molded PS products include products such as appliance housings, CD jewel cases, tumblers, flatware, and some EPS packaging. Expanded PS includes cups, shape-molded packaging, and packaging peanuts.

Exhibit 2 illustrates the percent of PS used in each of six major markets. Consumer and institutional products, including PS food service, is the largest category, with 41 percent of the total. Packaging is second, with 19 percent of the total use. (Source: 5) The packaging and food service, as estimated from previous studies, is 44 percent of total production. (Source: 6) PS sales in the US increased fairly steadily from 1991 to 1999. Sales peaked in 1999 and have declined since then, as shown in Exhibit 3. (Source: 7)

California production figures for PS must be estimated from national figures, since no data collected specifically for states is available. Table 2 illustrates the estimated California share of PS sales calculated based on population, according to U.S. Census data. The total California share of PS

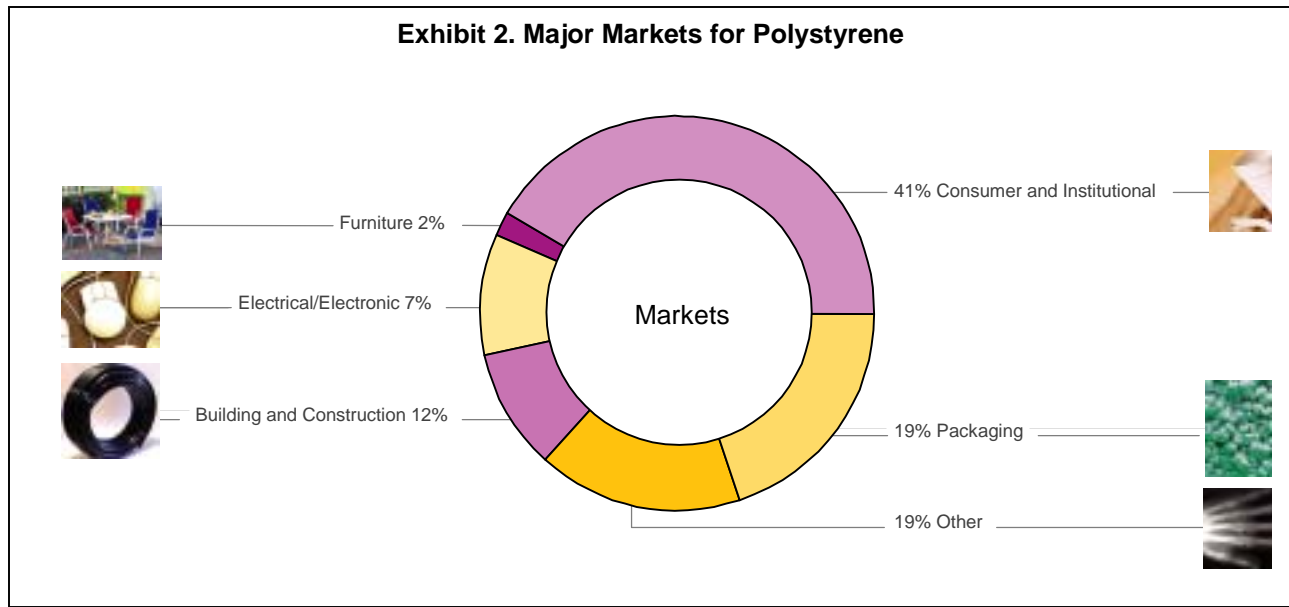
Table 1: Polystyrene Types and Typical Products

Polystyrene Type	Description	Typical Products
Crystal (rigid)	Transparent, can be injection molded or extruded, rigid, good clarity and stiffness.	Audio equipment, dust covers, clear audio tape cassette, and CD jewel cases; office supplies, computer disk reels, tumblers, flatware, housewares, display cases, petri dishes, pipettes, bottles.
Impact (rubberized)	Opaque, higher strength, less clarity and stiffness than crystal PS	Electronic appliance cabinets, business machine housings, video cassettes, small appliances, smoke detectors, furniture, refrigerator door liners, luggage, horticulture trays, dairy and yogurt containers.
Non-foamed PS sheet	Extruded or oriented, melted plastic is forced through a flat-faced die, extruded sheet is then thermoformed. Can use impact PS or crystal PS (for clear).	Glazing, decorative panels, cookie trays, document wrap, blister pack, salad containers, lids, plates and bowls.
Foamed PS sheet	Extruded, thermoformed, made by extruding crystal PS with a foaming agent (usually pentane), material is extruded through an annular die and foamed as the material exits the die, sheet thickness and density is varied to meet end-use requirements, has excellent thermal insulation qualities.	Egg cartons, meat and poultry trays, food service trays, fast food packaging, insulation, protective covers for glass bottles, plates, hinged containers, cups.
Expanded PS (EPS)	Made from PS resin granules impregnated with a blowing agent (typically pentane). Expanding beads fuse together to form the finished product, which is white, and 90 to 95 percent air (99.6 percent for loose fill). Small beads are used for cups and containers, medium beads for shape-molded packaging, and large beads for the expanded loose-fill packaging (peanuts). It insulates, is light weight, and resists moisture.	Insulation board, molds for metal casting, flotation devices, packaging (molded shapes, peanuts), cups, and containers.

production and sales are estimated at 377,579 tons. Applying the market share information to the California estimate, 77,006 tons is packaging, and 156,829 tons are consumer/institutional applications. The packaging and food service PS for California was an estimated 166,135 tons in 2001.

According to the Alliance of Foam Packaging Recyclers Association, 16 manufacturers of EPS foam packaging are in California operating at 22 locations. These facilities use an estimated 11,000 to 13,000 tons of resin per year, and employ more than 1,000 workers. The total number of firms in

Exhibit 2. Major Markets for Polystyrene



California manufacturing all types of PS is about 125. These firms employ more than 11,600 people, although some may be involved with other resins as well.

Recycling

While there is no meaningful food service recycling in the United States, several established recycling programs are available for non-food service PS. Three primary categories of materials are recycled:

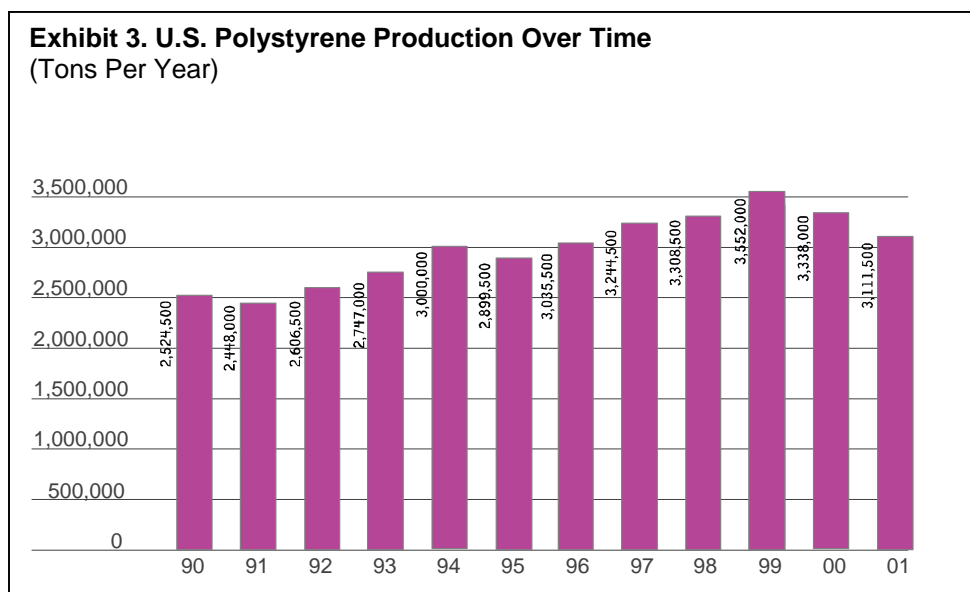
Transport packaging (EPS) is collected at

manufacturing facilities across the United States, including 15 in California (see Table 6).

Loose-fill packaging is also collected at these facilities as well as at packaging and mailbox locations across the country. More than 375 of these facilities are located in California.

A variety of non-foam PS products, such as CD cases, videocassettes, and agricultural trays, are also recycled. In addition, a small amount of PS food container recycling, as well as post-industrial PS scrap recycling, is collected from some institutional locations.

Exhibit 3. U.S. Polystyrene Production Over Time
(Tons Per Year)



National PS recycling quantities are shown in Exhibit 4 and Table 3. (Source: 8)

Table 4 illustrates the California share (by population) of PS recycled. (Source: 9) These estimates may be conservative, since California likely has a greater percentage of PS recycling due to the larger number of EPS recycling facilities statewide. Table 5 illustrates typical

Table 2: Estimated California Share of PS Production

Market	Tons
Packaging	77,006
Building and Construction	36,249
Electrical and Electronics	33,376
Furniture	5,885
Consumer and Institutional	156,829
Other	64,234
Total	377,579

recycling costs compared to recycled and virgin resin prices. (Source: 10) The margin between recycled resin prices and recycling costs is relatively small.

EPS Protective Packaging Recycling

The Alliance of Foam Packaging Recyclers (AFPR) was established in 1991 to help support foam

Table 3: National Postconsumer PS Types and Recycling Rates

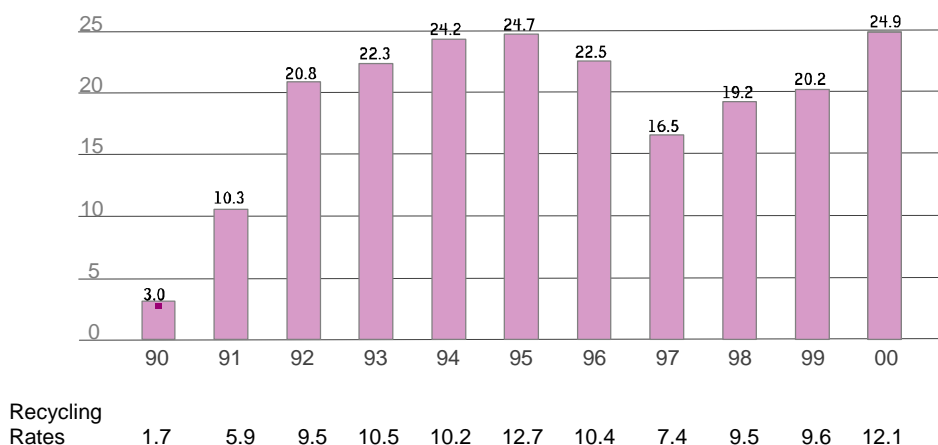
(Tons)

PS Type	1999	2000	Recycling Rate (2000)
Bottles and Containers	100	100	0.1%
Protective Packaging	10,100	12,450	12.4%
Food Service Packaging	3,250	2,250	0.2%
Other Applications	10,250	11,350	0.6%
Total Recycled	23,700	26,150	0.8%

packaging recycling. This is a trade association of more than 80 EPS protective packaging manufacturers, equipment manufacturers, and resin suppliers. More than 110 member plant locations nationwide—as well as many other non-member locations (such as loose-fill manufacturers)—collect EPS. The AFPR also will accept EPS packaging consumers send in the mail.

Most EPS recycling in California (and nationwide)

Exhibit 4. National EPS Postconsumer Recycling Rates and Quantities
(Millions of Pounds)



occurs through EPS manufacturing facilities. Fourteen facilities in California accept EPS packaging, as shown in Table 6. (Source: 11) These facilities take-back primarily molded EPS packaging. The estimated recycling rate is 19 to 23 percent, significantly higher than the national rate of 12 percent. California EPS manufacturers collected an

Table 4: California PS Production and Recycling Estimates, 2001

	CA Tons Produced	Recycling Rate	Tons Recycled
Bottles and Containers	7,552	0.1%	6
Protective Packaging	11,327	12.4%	1,405
Food Service Packaging	154,808	0.2%	310
Other Applications	203,893	0.6%	1,223
	377,580	0.8%	2,944

estimated 2,500 tons of post-consumer EPS in 2000, again significantly more than the estimated California share. (Source: 12)

Most EPS packaging is returned from larger manufacturers and distribution centers such as furniture and automobile manufacturers. For example, Ethan Allen is developing a collection system that could incorporate up to 300 stores and 26 distribution centers (two in California). To make the program economical, trucks backhaul EPS to the distribution centers, where it is collected and sent to a manufacturing facility. Transporting loose EPS by truck is economical within a 100-mile radius. If a backhaul vehicle is not available, costs range from \$85 to \$450 per shipment.

Larger manufacturers can densify the PS before shipping it to reduce costs. EPS collection programs from retailers are limited. Retailers are resistant to establishing collection systems, even with EPS industry support. The retailers do not want to give up valuable warehouse or parking lot spaces.

A few local governments provide drop-off programs for EPS. One EPS manufacturer, FP International, supports drop-off facilities in Palo Alto and San Mateo County. Contamination is more of an issue with these programs than the manufacturer take-back systems. Standards for EPS recycling are quite high. Manufacturers require material that is not contaminated with adhesives, film plastic, cardboard, dirt, etc.

Table 5: Typical PS Recycling Costs and Resin Prices

Type of PS Recycling	Cost or Price per Pound
Food Service Recycling Cost	\$.10 to .50
EPS Packaging Cost	\$.20 to .35
Recycled Resin Price	\$.38 to .45
Virgin Resin Price	\$.40 to .70

Materials that have been collected through a curbside program, or even left in a drop-off bin or outside in a storage yard, are usually too contaminated for end users. This contamination limits the amount of EPS material that can be recycled. As with other plastics recycling, the key to successful EPS recycling is obtaining sufficient quantities of clean material.

National Polystyrene Recycling Company

In the late 1980's, responding to growing consumer pressure and concern about landfill space in the United States, the PS industry initiated post consumer recycling programs. In 1989, industry established the National Polystyrene Recycling Company (NPRC) to recycle PS food service and

Table 6: EPS Packaging Collection Sites in California

Company	Location
1. Astrofoam Molding	Camarillo
2. Foam Fabricators	Modesto
3. Foam Fabricators	Compton
4. FP International	Commerce
5. FP International	Redwood City
6. Marko Foam Products, Inc.	Corona
7. Storopak, Inc.	Downey
8. Storopak, Inc.	Anaheim
9. Storopak, Inc.	San Jose
10. Styrotek, Inc.	Delano
11. Topper Plastics	Covina
12. Tuscarora Incorporated	Hayward

molded packaging. The NPRC was a \$16 million startup effort between eight corporations, including Amoco, ARCO, Chevron, Dow Chemical, and Mobil. The five facilities (and one affiliated facility) had a goal of a 25 percent recycling rate for food service and packaging PS by 1995.

While technically feasible, food service PS is difficult to recycle due to being contaminated with food, transportation challenges due to its light weight, and collection difficulties. The corporations involved with the NPRC invested \$85 million between 1989 and 1997 to operate the recycling facilities, yet never achieved profitability. (Source: 13) Industry found that there was reluctance among organizations, businesses, and consumers to collect food service PS for recycling. As with other resin types, it was difficult for the recycled resin to compete with virgin PS on both a cost and quality basis.

There is virtually no recycling of food service PS in California. However, since 1990 Michigan-based Dart Container has assisted companies wanting to recycle by leasing them a densifier for \$295 per month and backhauling the material to a recycling facility. Although there were a limited number of California facilities participating, none are currently. According to Dart Container representatives, customers were not willing to pay for the densifier or allocate the labor necessary to sort and process the material.

Canadian Polystyrene Recycling Association

For similar reasons and at about the same time that NPRC was starting in the United States, a similar effort was started in Canada. However, the Canadian Polystyrene Recycling Association (CPRA) is still in operation, while the NPRC is not. In an August 2003 interview, CPRA President John Roulston provided an insight into CPRA's operation and why it is successful.

CPRA processes 20–25 tons of material per day, five to six days per week. It receives material primarily from three areas: (1) approximately 20–25 percent of its material comes from the horticultural industry (trays and flats), (2) a significant (undetermined) percentage comes from commercial packaging and graphic industrial signs, and (3)

about 5–10 percent comes from its curbside collection program (referred to as the Blue Box) which serves approximately one million households.

CPRA pays materials recovery facilities approximately \$50 ton (U.S. dollars), F.O.B. CPRA's facility. The manufacturing operation provides approximately 96 percent of revenues, with membership fees providing the remaining four percent. The membership fees roughly cover the cost of the educational outreach program. Although CPRA's operations were subsidized for the first decade, it has not required a subsidy for plant operations since 2000. It also received tax incentives from the province.

CPRA produces a single product, a 100 percent postconsumer black high-impact PS (HIPS). Approximately half the sales are to the horticultural industry with the balance being used in non-critical application, such as office products. Part of CPRA's success can be attributed to its management style. The corporate culture is more similar to that of a recycling entrepreneur rather than a large corporate bureaucracy. Although governed by a Board of Directors, CPRA's management team is given the authority and responsibility to efficiently run the operation.

Loose Fill Packaging Recycling and Reuse and Other Recycling

A second major area of PS recycling and reuse is loose fill packaging, or peanuts. In 1991, the nation's four major EPS loose fill manufacturers established the Plastic Loose Fill Council (PLFC). (Source: 14) Loose fill packaging customers, such as mail order companies, established the reuse program in part because of environmental concerns.

Two companies, FP International and Storopack, Inc., operate plants that produce and recycle EPS loose fill in California. FPI locations include Redwood City and Commerce. Storopack locations include Anaheim, Downey, and San Jose. Since its inception in 1991, industry has paid over \$650,000 in program infrastructure costs. These costs include the toll-free 800 number and, for the first several years, a staff person to answer hotline questions. (Source: 15)

The PLFC operates a national manufacturer-sponsored postconsumer EPS packaging take-back program. The program provides a toll-free Peanut Hotline* to provide callers with the nearest location that accepts loose fill packaging for reuse. The hotline receives about 5,000 calls a month.

In addition, more than 200 mail order and other companies include a flier with information on the program in their packaging. Many communities list information on the program in recycling guides. More than 375 locations in California, and more than 1,500 nationwide, participate in the program. Take-back locations primarily include The UPS Store, Mail Boxes Etc., and other similar packaging stores.

The program has broad benefits to all participants. Collection sites provide improved customer service, and businesses are able to reduce their purchase of new packaging peanuts by 50 percent by reusing returned peanuts. Industry reuse of peanuts is estimated at 30 percent of the 22,500 tons of loose fill manufactured each year. The reuse rate for EPS in California is estimated at between 20 and 30 percent, a total of about 500 tons per year.

Other types of PS recycling make up about 43 percent of the total PS recycled. Materials recycled include insulation board, audio and VHS cassettes, CD jewel boxes, and nursery trays and containers. Most of these materials are recycled through commercial sources, not curbside programs.

Composting/Biodegradable Products

Compostable and biodegradable plastics are a technological innovation that may eventually serve as a replacement for some PS food service products—cups, “clamshells,” plates, and cutlery. These items are often found in litter. Several companies have developed or are developing compostable and/or biodegradable alternatives while other, such as McDonald’s, are testing products.

There are several products and processes that claim to be compostable or biodegradable. While these materials may not be currently competitive in terms of price or some quality characteristics, they appear to hold significant promise.

The value of biodegradable food service packaging is two-fold: (1) institutional users can incorporate the packaging into new small-scale food composting collection systems without the labor and expense of separating the container from the food and (2) if the material is improperly disposed or blows out of trash cans, the negative impact on wildlife and storm drain systems is minimized when the material biodegrades.

The CIWMB has formed a diverse working group of stakeholders to identify the issues and responses that may be necessary for decision makers to form sound public policy based on facts and science. In addition to developing information to educate and inform decision makers, the group will identify additional testing, pilot programs, specifications, etc. that may be needed for decision makers to determine whether the state should support such efforts and what form that support may take.

We must realize that using biodegradable food service products will not eliminate litter problems. Some would argue that it may even increase litter if consumers believe that it no longer poses an environmental problem.

Conversion Technology

A new form of recycling that holds significant potential is “feedstock recycling” or “chemical recycling,” more commonly referred to as “conversion technology.” Conversion technology (CT) refers to the processing of solid waste, through noncombustive thermal, chemical, or biological processes, other than composting, to produce products such as electricity, fuels, or chemicals that meet quality standards in the marketplace. CT includes, but is not limited to, catalytic cracking, gasification, and pyrolysis.

Basically, plastic is processed through one of the methods to produce a marketable product, such as fuel or gas. These products can be used to fuel vehicles or power generators as a form of “green,” or renewable, energy. Some methods can also produce the original monomers (plastic resin). While CT processes hold significant long-term potential, it is unclear at this time how much PS can be recycled using CT. It is also unclear whether projects can be economically self-sufficient or what

*Peanut Hotline number: (800) 282-2214

kind and/or level of subsidy, if any, may be needed to support the activity.

Generally, curbside programs are not able to generate adequate quantities or quality for use by EPS manufacturers. Contamination issues with PS suggest that conversion of the PS into fuel or other products may be a potential alternative for diverting PS that is not readily recyclable.

CT is considered “cutting-edge” technology, and there are only a few operating facilities in the world. One such facility under construction is the Plastic Energy, LLC facility located at the Kings County

Material Recovery Facility. This facility intends to use post-recovered plastics (after recyclable

materials have been removed) to produce an ultra-low sulfur diesel fuel. Waste Management, Inc., has already agreed to provide post-recovered plastics and use the resulting diesel in its vehicle fleet. The CIWMB provided a \$2 million low-interest equipment loan through its Recycling Market Development Zone loan program for the facility.

Chapter 740, Statutes of 2002 (AB 2770, Matthews) allocated \$1.5 million for the CIWMB, in consultation with other federal and State entities, to prepare a report to the Legislature on new and emerging conversion technologies (CT).

Holiday EPS Collection Project

The challenges of EPS collection from consumers after Christmas were demonstrated in Long Beach in December 2002. The goals for the one-day event were to increase awareness of plastics recycling and to offer a special event in which EPS material generated over the holidays could be collected and recycled. The Alliance of Foam Packaging Recyclers (AFPR), the City of Long Beach, the American Plastics Council (APC), FP International, Tuscarora Incorporated, and the CIWMB organized the program. AFPR has 10 years experience in facilitating EPS Christmas collection programs and the City of Long Beach has a long-standing reputation of being successful and innovative with recycling.

After considering a variety of alternatives, it was decided to conduct the EPS collection in conjunction with the city's Christmas tree collection program. This provided an opportunity to leverage a long-standing post-holiday recycling activity (recycling Christmas trees) for consumers. Several different approaches were taken to advertise the program. Advertisements in the local paper for the Christmas tree collection were edited to include information about dropping off EPS at the same locations. Where existing ads could not be edited, new ads were placed next to the Christmas tree announcements. Approximately 72,000 flyers were distributed to area school children to take to their parents and approximately 5,000 paycheck stuffers were provided to City of Long Beach employees. Press releases were issued to local TV, radio, and print media in addition to distribution of flyers at local Circuit City and Wal-Mart stores. Additionally, EPS recycling posters were distributed to schools and city government buildings. Organizers estimate that over 50,000 households were informed of the collection event.

The EPS collection took place at 11 locations on Saturday, December 28, 2002. A total of approximately 200 pounds of EPS was collected from all 11 locations. Costs for the project totaled over \$22,000, including promotion/advertising, the trailer to haul the EPS, and other costs. This is in addition to an estimated 1,200 man hours contributed to the project.

The results were consistent with most other efforts undertaken by the participants in large metropolitan areas. However, the holiday collection program has been successful in smaller cities when heavily promoted by local media and PS producers. If this type of promotion is planned in the future, it may need to be approached differently in order to provide a better opportunity for success. (Source: 16)

Markets For Recycled Polystyrene

Several markets are available for EPS in both closed- and open-loop recycling. Sufficient end markets are available for all the clean EPS collected. Almost half of the EPS packaging recycled—both molded and loose fill—is remanufactured back into EPS packaging.

Other applications for EPS recycling include building applications such as siding and deck board, ceiling texture, molding, electronic products, auto products, agricultural products, office supplies, egg cartons, and beanbag filler. Markets for non-foam PS include coat hangers, picture frames, waste baskets, videocassettes, flowerpots, and nursery trays.

Companies that produce non-foam rigid PS products consume about 25 percent of the EPS packaging recycled. EPS molders consume about 50 percent, and loose fill manufacturers purchase the remaining 25 percent. The amount of material currently available limits the recycled-content level in molded EPS to about 2 percent post consumer material. (Source: 17)

Recycled-content levels in EPS molded packaging can be as high as 25 percent, but they are typically much lower. (Source: 18) These levels could increase in the future. One manufacturer of EPS recycling equipment recently obtained acceptable ASTM standards with EPS made with 20 percent and 40 percent regrind (recycled content). (Source: 19) Applications with higher cushioning requirements may need to use a lower recycled-content level.

Molders typically incorporate recycled content into their products by blending in used expanded beads from products they take in and grind down to bead levels. (Source: 20) Because the recycled EPS is not re-blown, it has a different shape and can only be used in limited quantities.

This material serves primarily as “dead filler” material because it lacks a blowing agent. Due to design restrictions, molded EPS—especially thin material—can tolerate 5 to 10 percent recycled EPS

without a loss in quality characteristics. Less demanding applications, such as EPS block manufacturing, can tolerate higher levels.

Another primary market for recycled EPS molded packaging is the production of loose fill packaging. Loose fill manufacturers are active in EPS collection programs. Loose fill typically ranges from 25 percent to 100 percent recycled content (depending on producer), although the content is not 100 percent post consumer.

More than 65 percent of the EPS one California manufacturer uses is postconsumer. If loose fill continues to be reused in the take-back program, material could potentially be diverted from the landfill for many cycles of use.

The building and construction industry, including several companies located in California, provides a number of markets for PS. Rastra Building Systems produces a concrete form made of 85 percent recycled PS. The material is produced at two locations in California that have a combined capacity of 156 tons per year.

Timbron, a Stockton based company, densifies EPS to produce interior moldings and other similar products that can be sawed and nailed like wood. Timbron products are sold at Home Depot stores. EPS constitutes 75 percent of the company’s finished products, with demand at more than 18 million pounds annually.

Timbron provides large suppliers of recycled EPS with a \$60,000 densifier as well as support for labor in collecting and densifying the material. Suppliers include HP, Epson, Sony, Panasonic, Marko Foam Products, and Tatung America. Timbron uses both postconsumer and post-industrial EPS. The company received a \$1 million loan from the CIWMB’s Recycling Market Development Zone loan program in 1999.

High impact PS (HIPS) is used in various electronic devices, such as casings for televisions, computers, and telephones. It is also used for office products such as file trays and rulers, horticultural trays, and many other products. While there are currently no reliable figures for the potential market, the CPRA operation reportedly does not have any problem

selling its production of approximately 20 tons per day in the open market.

Disposal

In 1999, an estimated 300,000 tons of PS was landfilled in California. (Source: 21) This amount is relatively small in terms of overall waste generation—only 0.8 percent (by weight) of the total waste landfilled in California. Even considering volume rather than weight, PS in the waste stream does not appear to pose significant problems related to landfill capacity.

PS disposal is no different than any other material. If users do not recycle their PS, they dispose of it with other solid wastes. EPS is a very bulky material, so a consumer who purchased a new appliance with EPS protective packaging could fill a trash can with foam that week. Another potential PS disposal problem, discussed below, results when fast-food containers (cups, plates, clamshells) either spill over or blow out from trash receptacles. Because the EPS material is so light, it can blow away, becoming litter. This release into the environment is one of the key concerns with food service PS.

The cost of PS disposal can be calculated from typical disposal cost figures, since it will be collected with other solid waste from both commercial and residential sources. Typical solid waste collection costs in California are \$100 per ton, including collection and an average tipping fee of \$30 per ton. Total disposal costs for PS are estimated at about \$30 million per year. (Source: 22) These costs are covered through solid waste fees paid by residential and commercial users, like all other solid wastes. This does not take into consideration the cost of collection and disposal of litter, which can result in a significantly higher cost (see Environmental Impacts).

Environmental and Health Impacts

The three key areas discussed in this section are lifecycle impacts, health impacts, and environmental impacts. When compared to many alternatives, the lifecycle impacts of PS products that are properly disposed or recycled are positive and should be recognized. The health impacts of PS have been

controversial at times but appear to be minimal. The primary environmental impact of PS relates to litter and improperly disposed PS, particularly in the marine environment. This is the key issue of concern for PS, and it should be addressed in future industry deliberations and policy-making. Each of these areas is summarized briefly, below.

Life-Cycle Impacts

Life-cycle impacts include numerous aspects such as exploration, extraction, and refining of oil, production and transportation, and use and disposal (including the social and environmental impacts of illegal disposal—litter). Unfortunately, most of the analysis identified is limited in scope or compares PS to an alternative product.

In general, PS protective packaging is light, strong, and effective in protecting a wide range of products. It reduces breakage and the total weight of waste disposed as compared to other alternatives. PS containers used to ship produce and fish provide insulation, and they have demonstrated the ability to keep food fresher than typical wood or cardboard containers.

One study found that EPS boxes were more effective than corrugated cardboard boxes for shipping fresh fruits and vegetables. The benefits of EPS included controlling acidity, maintaining solid content, reducing pigment loss, reducing vitamin loss, and extending freshness. (Source: 23)

A life-cycle analysis comparing foam PS and bleached paperboard plates, cups, and hinged containers found that the PS containers require 30 percent less energy than the paper containers. PS containers contributed 29 percent more to solid waste volume, and they have 46 percent lower atmospheric emissions. They contributed 42 percent less waterborne wastes. (Source: 24)

Martin B. Hocking of the University of Victoria, British Columbia, Department of Chemistry, observed similar findings. With respect to overall energy costs during fabrication and use, reusable cups have similar energy consumption to single-use PS foam cups after 500 uses. (Source: 25) Polystyrene cups were found to have the lowest energy consumption. Hocking also notes that paper

cups result in additional chemical use and emissions as compared to PS cups. (Source: 26)

After extensive environmental impact assessment, the Danish Environmental Protection Agency determined the burdens on the environment of various packaging materials. Packaging materials were reviewed looking at energy consumption, CO₂ emission, environmental effects, consumption of fossil resources, and waste. They ranked various materials from highest to least impact: aluminum, steel, polyvinyl chloride, EPS, PS, polyethylene terephthalate (PET), polypropylene, glass, and cardboard. (Source: 27)

These life-cycle studies, while not always considering all external pathways, highlight the overall benefits of PS. In some cases, PS is superior in a variety of ways to several alternative products. Provided PS is used appropriately and reused, recycled, or disposed of properly, it appears to have net positive impacts. High costs arise when PS products are disposed of improperly: either littered or accidentally knocked out of, or blown out of, overflowing trash receptacles. These problems are discussed below.

Health Impacts

The most commonly raised health issue related to PS is the migration of the monomer (styrene) used in the production of PS from PS food containers into food and drinks. PS is not designed to be used in a microwave oven because styrene has been shown to migrate from PS containers in small amounts, especially when energy (heat) is applied. Styrene is one of the most widely used organic chemicals. It is used in the production of thousands of products, including containers, cars, boats, computers, medical equipment, and safety equipment. (Source: 28) Styrene is derived from petroleum and natural gas, and it occurs naturally in some plants and foods.

It is not known whether styrene can cause cancer in humans. Styrene is classified by the International Agency for Research on Cancer as possibly carcinogenic to humans, but the American Conference of Governmental Industrial Hygienists does not classify it as a human carcinogen. (Source: 29)

Styrene does not appear to bioaccumulate. When people are exposed to high doses, most (90 percent) of styrene is excreted from the body within hours, and from fat within several days. Styrene degrades in the atmosphere, volatilizes from water, and is biodegraded by aerobic microorganisms in the soil. (Source: 30)

Exposure to styrene occurs from a number of sources, including air (from gasoline combustion and industrial sources), water, cigarette smoke, exposure to waxes and products with styrene, and ingestion (from natural sources, migration, or additives). Potential migration of styrene from food containers is a minor source of styrene. A number of studies have found small concentrations of styrene in human tissue. (Source: 31)

Styrene is not without health impacts. Styrene has central and peripheral nervous system effects in workers exposed to high levels. (Source: 32) Symptoms include headache, fatigue, weakness, depression, and a feeling of drunkenness. Symptoms are alleviated when one is no longer exposed to styrene. Styrene can also cause eye and mucous membrane irritation, and there are concerns about potential hearing loss with long-term, high-level exposure. These impacts are found at significantly higher exposure levels than ambient styrene concentrations.

A study conducted by the Harvard Center for Risk Analysis found “no cause for concern for exposures from contact with products made with styrene, including food contact products such as packaging and serving containers.” The National Institutes of Health Toxnet database, which includes more than 100 pages of research summaries on styrene, supports these findings.

Environmental Impacts

The most significant environmental impact from PS results from the improper disposal (littering) of PS containers. PS is a significant component in coastal litter collection programs and monitoring studies. In the 1999 U.S. Coastal Cleanup (a one-day nationwide cleanup event held each fall), foamed PS pieces were the fourth-largest amount of all material collected. This represents more than 5 percent of the total number of pieces collected. (Source: 33)

Table 7: U.S. Coastal Cleanup Results—Foam, 1999

Foamed Plastic	Pieces	Foam Percent	Total Percent
1. Buoys	13,609	3.0%	0.3%
2. Cups	84,652	18.4%	2.0%
3. Egg cartons	3,503	0.8%	0.1%
4. Fast food containers	26,880	5.8%	0.6%
5. Meat trays	8,688	1.9%	0.2%
6. Packaging materials	48,329	10.5%	1.2%
7. Foamed PS pieces	214,960	46.6%	5.1%
8. Plates	17,997	3.9%	0.4%
9. Other foamed plastic	42,506	9.2%	1.0%
Total Foamed Plastic	461,124	100.0%	11.0%
Total Pieces	4,191,169		

Only cigarette butts, plastic pieces, and plastic food bags and wrappers were collected in amounts higher than foam pieces. As shown in Table 7, the nine categories of foam—including fast-food containers, cups, egg cartons, and plates—accounted for 11 percent of the total number of pieces collected, a total of 461,124 pieces of foam products. (Source: 34)

California accounted for 20 percent, by weight, of the total tonnage of material collected in the U.S. Coastal Cleanup Day in 1999. A study conducted from August to September 1998 quantified California beach debris from 43 random sites from Seal Beach to San Clemente. (Source: 35) The most abundant item was pre-production plastic pellets, followed by foamed plastic, shown in Table 8. (Source: 36)

Even studies measuring plastics found up to 5 km off the Southern California coast have found high levels of small plastic pieces from land-based

sources, especially after storm events. (Source: 37) These small plastic pieces, similar in size to plankton and more abundant than plankton, represent a particular risk to filter feeders.

PS in the marine environment results in significant problems for wildlife. Entanglement, smothering, and interference with digestive systems threaten more than 265 species of marine and coastal wildlife. (Source: 38)

PS is of particular concern because it is light, it floats, and it is highly visible. In addition, PS foam breaks into small pieces, increasing the chance of ingestion by wildlife and increasing the difficulty and cost of collection. Ingestion of polystyrene pieces, which look like food to many species, results in reduced appetite, reduced nutrient absorption, and starvation for wildlife.

Marine debris also creates problems for fishermen and recreational boaters, particularly when plastics get into boat engines and cause damage.

Scientists have identified new areas of concern related to floatable plastic litter. One problem is the adsorption of toxic substances in sea water into plastic resin pellets. Another is the transportation of invasive species such as barnacles, mollusks, sea worms, and corals that travel on plastic litter “boats” to islands and other sensitive ecosystems. (Source: 39)

Finally, PS litter has negative impacts on tourism in California. The state has more than 1,000 miles of coastline, so maintaining clean beaches and coastal areas is important to its tourism industry.

The nature of the PS use—for disposable single-use consumption, often at fast-food restaurants—may increase the likelihood that the material will be disposed of improperly. Also, because of its light weight, even properly disposed containers in full trash receptacles may end up blowing away and becoming litter.

PS is not the only material entering storm drains as trash. But because of its high visibility, PS is of particular concern in storm drains. PS is one of the trash items most commonly found in storm drains in Los Angeles County. (Source: 40) Cities in this area began focusing efforts to eliminate trash in storm

drains during the next 10 years as part of the TMDL

Table 8: Estimated Total Abundance and Weight of Trash on Orange County Beaches

August to September, 1999

Debris Type	Number	Weight (pounds)
1. Pre-production plastic pellets	105,161,101	4,780
2. Foamed plastics	742,296	1,526
3. Hard plastics	642,020	7,910
4. Cigarette butts	139,447	344
5. Paper	67,582	870
6. Wood	27,919	4,554
7. Metal	23,500	3,015
8. Glass	22,195	1,944
9. Rubber	10,742	817
10. Pet and bird droppings	9,388	17
11. Cloth	5,949	1,432
12. Other	10,363	401

requirements. Each city in Los Angeles County recently agreed to jointly pay the consultant costs to determine the best option to comply with the TMDL requirements. Initial indications are that the cost of TMDL compliance is estimated at \$168 million or more.

Trash from Long Beach and Signal Hill storm drains accumulates in a particular location during the summer. An estimated one-fifth to one-third of this trash was estimated to be white PS cups and clamshell containers (followed by plastic water bottles and plastic bags). (Source: 41)

Litter is a pervasive problem involving diffuse sources and human behavior with no easy solutions. Specific materials such as PS do not cause the litter problem; rather, it is caused by human behavior. Whatever the cause, the high costs of litter cleanup and collection are a significant economic externality of plastics. This is especially true of PS. The

problem should be addressed in public policy and/or industry-led initiatives.

A Seattle Times article estimated the cost of collecting litter at \$1.11 per pound. (Source: 42) In Orange County, the cost of collecting litter on 6 miles of beach for one summer is \$350,000. (Source: 43) The total litter collection costs for cleaning up 19 beaches along 31 miles in Los Angeles County was more than \$4 million in 1994.

The City of Long Beach and Los Angeles County currently spend about \$1 million a year on litter collection in Long Beach Harbor, at the mouth of the Los Angeles River. (Source: 44) Using a figure of about 3,000 tons collected from 1998 to 1999, the collection cost is more than \$300 per ton. The Los Angeles County Department of Public Works also contracts out the cleaning of more than 751,000 catch basins for a total cost of more than \$1 million per year. (Source: 45)

While aggressively enforcing State and local litter laws is a good first step, this effort alone is unlikely to achieve the mandated zero-tolerance levels. Enforcement is also the least costly policy option, estimated to cost less than \$1 million per year. (Source: 46)

Approaches to Manage Plastics

Should Certain Plastic Products or Packaging Be Banned?

Bans on the sale of plastic products are sometimes proposed as a means to solve plastic issues. Two potential plastic bans are most often mentioned: PVC containers, which are a contaminant in PET recycling, and PS food service containers, which are not currently recycled due to economics. Food containers are a major component of litter in storm drains.

While bans may help solve immediate problems, they are generally not an effective long-term solution. Banning PS products and containers would help reduce the problem with the illegal disposal (litter) of PS products. However, some other new container type may be developed that would also create litter problems. Implementing a processing

fee that covers the extra costs of recycling PS products and containers in a processing fee might be a more effective solution than banning them.

Encouraging and promoting alternatives could be more effective than bans in solving problems posed by plastic materials. These alternatives could include biodegradable food service containers—used in conjunction with food composting—and extensive litter reduction efforts. Bans are narrow in scope, addressing a very specific problem with a very specific solution. This narrow approach is an ineffective means of addressing a material with the global applications and ramifications of plastics. While they have, in some cases, been effective in bringing about change, policy makers should only use bans as a last resort.

Should Plastic Manufacturers Be Assessed Additional Plastic Payments?

Some members of the plastics industry have already made significant contributions to plastics recycling in California. However, industry could provide increased funding support, especially as part of a broad collaborative initiative. Such an effort is likely to be more successful than the independent and more discrete industry efforts of the past.

Industry could expand its support of plastics initiatives in a number of different ways. These could include funding specific earmarked programs or mandatory fees or deposits. Another option would be voluntary deposit systems paid into a plastics fund based on sales in California, with the payment amount to be determined. Mandatory fees will be unpopular among industry groups and complicated to implement for both government and industry. However, policy makers can develop fee systems that would be fair and acceptable.

Mandatory deposits could be complicated if they are not blended into the existing California Bottle Bill system, currently administered by the Department of Conservation. A voluntary deposit system may be appropriate for some products or packages, and industry should consider these systems. Two examples of potential voluntary deposits are the Alberta Dairy Council Plastic Milk Container Recycling Program, and deposits on car batteries to encourage returns to the retailer.

Industry groups may also choose to self-fund initiatives for their products and packaging, such as the Plastic Loosefill Council's recycling program for packaging peanuts. However, these programs all provide funding for fairly specific products and packaging.

For more generalized industry support of plastics recycling and resource conservation, one alternative would be to establish a payment based on sales of plastic packaging, products and resin in California. Exemptions could be allowed for packaging and products with a certain level of postconsumer material and for postconsumer resin. This payment could then be used to fund new plastic policy initiatives.

The agreed-upon collaborative entity could develop specific criteria for uses of the funds generated through one of the above mechanisms. Companies could choose to contribute to the fund voluntarily, or the fee could be mandatory. This type of fee would be much simpler to implement than an advanced disposal fee on individual products or packages sold in the state.

Plastics White Paper

Most would agree that while there are many advantages to the use of PS, there are also some drawbacks. While there can be some improvements in the effective management of PS in California, what is needed is a comprehensive approach to managing all plastics, not just PS.

Plastics are the fastest-growing segment of the waste stream, often replacing other materials. It represents an estimated 8.9 percent (by weight) and perhaps twice that amount (by volume) of materials disposed of in landfills. That ranks plastics as the second largest (behind paper) category of material (by volume) being landfilled. Plastics recycling is stalled at approximately 5 percent, much lower than many other materials. Most of the current recycling is from beverage containers.

With some exceptions, the plastics industry is not adequately addressing plastics shortcomings on its own. Currently, there is no comprehensive policy for plastics in California. The two existing Board programs (pertaining to regulated plastic trash bags and non-exempt rigid plastic packaging containers)

combined address only a small percentage of the materials disposed in landfills. Additionally, the Beverage Container Recycling Program at the Department of Conservation (DOC) targets various beverage containers sold in the state.

The Board, in partnership with DOC, recognized the need to address the above issues and contracted with NewPoint Group, Inc. (NPG). NPG assisted the Board, DOC, and stakeholders in identifying and analyzing the manufacturing and use cycle of plastics and in creating and developing innovative solutions to: (1) conserve resources, (2) increase the plastics recycling rate, and (3) increase the use of recycled plastics.

National Packaging Covenant

An approach used to reduce packaging waste in Australia and New Zealand is the National Packaging Covenant (NPC). Initiated in 1999 by the Australian and New Zealand Environment & Conservation Council, the NPC is a collaborative approach between state government, local government, and the entire packaging supply chain (and relevant industry associations). The NPC is a voluntary, self-regulatory approach to provide improved management of used packaging based on the principles of product stewardship and shared responsibility.

The NPC system has two main components:

- The Covenant serves as a framework or umbrella document. As the primary document, it sets broad parameters, covers the entire packaging supply chain, is self regulatory, not prescriptive (does not mandate how companies comply), and has a limited life span (five years).
- The Regulatory Safety Net or National Environment Protection Measure (NEPM) is designed to support the NPC and, in an effort to ensure consistency, include those who did not sign the Covenant. The NEPM includes “take back” requirements with the focus on “brandowners” (such as large grocery chains). Brandowners’ participation is necessary due to their position as key decision-makers and their ability to influence the supply chain as customers of packaging manufacturers.

The NPC includes action plans for each participant that set forth specific measures and activities. Associations may prepare plans for an industry group or local governments. There are also provisions for funding the operation.

While the NPC is still relatively new, early indications are encouraging. It is favorably received by the packaging industry because it allows them to develop their own action plans and method of compliance. It also avoids potentially more onerous laws and regulations. It is also supported by most of the environmental community and government sector.

Rates and Dates

Another approach was proposed in 2001 by Senate Bill 1069 (Chesbro). If passed, the bill would, among other things, impose a plastic pollution fee on manufacturers of containers for every plastic container of a resin type that does not achieve a 50 percent recycling rate by a future date. The fee would not apply to beverage containers as defined by the California Beverage Container Recycling and Litter Reduction Act.

The fee would be the difference between the average cost of recycling and the average scrap value of each resin type. The monies will be used to promote the recycling of plastic containers, including payments to recyclers and local governments to offset the cost of recycling plastic containers.

If the 50 percent recycling rate goal is not met, the proposed law would impose an economic transfer from manufacturers to recyclers to reduce the cost of recycling. That would decrease the cost of recycled plastic and, presumably, increase its use.

Proponents of this “rates and dates” approach claim it is needed to motivate responsible parties and would allow flexibility in how to achieve the recycling goals. Opponents argue that it sets arbitrary and political goals with little, if any, economic or environmental rationale and without considering the numerous technical and logistical issues.

Zero Waste

In its 2001 Strategic Plan, the CIWMB determined that it will “Promote a ‘zero-waste California’

where the public, industry, and government strive to reduce, reuse, or recycle all municipal solid waste materials back into nature or the marketplace in a manner that protects human health and the environment and honors the principles of California’s Integrated Waste Management Act. “The Zero Waste philosophy focuses on the most efficient use of natural resources in order to maximize the reduction of waste and protect the environment.

It also includes, but is not limited to, maximizing recycling and ensuring that products are designed for reuse or repair or are recycled back into the environment. Zero Waste involves utilizing the most effective industry processing or manufacturing practices to efficiently conserve the use of raw materials, including front-end design for efficiency while educating consumers.

It includes promoting technology to encourage source reduction on the front end and recycling and other technologies on the back end, while harnessing the energy potential in “waste” by using new and clean technology to convert materials directly into green fuel or gas for the production of electricity.

Recommendations

General

No separate PS legislative initiative is warranted. California should develop a comprehensive approach to managing all plastics, not just PS. Development of this comprehensive and cohesive solution should be a collaborative process of all stakeholders, led by the State.

This effort may contain elements found in approaches used in other countries, such as Australia, Canada, the European Union, and previously proposed California legislation.

It should contain elements in at least the following four areas:

1. Product stewardship and financial responsibility.
2. Collection and market development.

3. Public information, public relations, and education.
4. Research and development of technologies.

These activities should be directed toward a “zero-waste” goal, with interim objectives for making progress toward that goal.

Elements from the Plastics White Paper that specifically pertain to PS include the following:

Reducing Discards and Litter

The solution to the problem will likely include a number of approaches that will require the support and participation of all involved. These efforts include:

1. The State should increase effective litter education efforts through collaboration and coordination between all State entities that spend money on anti-litter education and/or cleanup. This effort could be led by the Department of Transportation or the Department of Conservation and include other involved parties (local government, environmentalists, food service packaging producers, fast-food restaurants, and others). The effort should leverage resources and deliver a consistent message whenever possible.
2. The Legislature should explore making litter a civil offense, to facilitate issuing litter tickets. Legislation should provide financial incentive, perhaps from proceeds of violation tickets, to individuals and/or organizations that identify violators with appropriate proof (such as videotape or witness testimony) that results in tickets being issued.

Compostable and Biodegradable Plastics

The Legislature should appropriate monies (leveraged by private sector funding) to perform appropriate studies and testing and produce demonstration projects to determine the feasibility of compostable and biodegradable plastics as alternatives to non-degradable (traditional) plastics.

Conversion Technologies

CIWMB should ensure that CTs using plastics as a raw material are considered in the current evaluation process and resulting report to the Legislature.

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